What is claimed is:

1. A method performed by a computer for generating a geometric pattern from an image having a plurality of ridges and mesh points, the method comprising the steps of:

forming a partial differential equation by transferring values for positions in the image to corresponding coefficients of the partial differential equation;

determining simultaneous difference equations corresponding to the partial differential equation and the image mesh points;

solving the simultaneous difference equations; and

mapping the solutions of the simultaneous difference equations to respective positions on the image to determine features of the image.

2. The method of claim 1, wherein the image is a fingerprint.

3. The method of claim 1, wherein the image is a facial image.

4. The method of claim 1, wherein the image is a hand-palm image.

5. The method of claim 1, wherein the image is an eye iris image.

6. The method of claim 1, wherein the image is a texture image.

7. The method of claim 1, wherein the image is an eye retina image.

8. The method of claim 1, wherein the step of forming a partial differential equation comprises the steps of:

calculating a plurality of intrinsic properties of the image according to image ridge pattern;

mapping the plurality of intrinsic properties into coefficients of the partial differential equation; and

determining a boundary condition for the partial differential equation from the image to establish a relationship between properties of the image and the partial differential equation.

9. The method of claim 1, wherein the step of determining simultaneous difference equations comprises the step of replacing each derivative and variable items of the partial differential equation with respect to each mesh point in the image.

10. The method of claim 1, wherein the step of forming a partial differential equation comprises the steps of:

determining initial conditions for the partial differential equation; and

determining boundary condition for the partial differential equation.

11. The method of claim 10, wherein the step of determining initial conditions comprises the steps of:

normalizing the image to reduce variations in gray-level values along ridges of the image;

estimating property values of the image; and

mapping the estimated property values into weight coefficients of the partial differential equation.

12. The method of claim 10, wherein the step of determining boundary condition comprises the steps of:

drawing a close boundary within the image; and

setting boundary condition on the drawn boundary.

13. The method of claim 11, wherein the step of normalizing comprises the steps of:

determining M, mean of the gray-level in a region R by computing

$$M=(1/N)\sum\sum_{(I,J)\in R} F(I,J) \qquad (2a)$$

where N is total number pixels in the region R; F(I, J) is gray value of the image at point (I, J);

determining V, variance of the region R by computing

$$V=(1/N)\sum\sum_{(I,J)\in R}(F(I,J)-M(F))*(F(I,J)-M(F)) \qquad (2b);\ \text{and}$$

determining a normalized region R by computing

$$\begin{aligned} &R(I,J)=m+\mathrm{sqrt}((v*(F(I,J)-M)*(F(I,J)-M))/V), \text{if } (I,J)>M; \\ &R(I,J)=m-\mathrm{sqrt}((v*(F(I,J)-M)*(F(I,J)-M))/V), \text{otherwise} \end{aligned} \qquad (2c)$$

where m and v are the desired mean and variance values, respectively.

14. The method of claim 11, wherein the step of estimating property values comprises the steps of:

dividing a region R into blocks of size b*b as B(k);

computing gradients at each pixel in R as

$$\begin{aligned} &\partial x(I,J)=(p1*F(I-d,J)+p2*F(I,J)+p3*(F(I+d,J))/p, \\ &\partial y(I,J)=(p1*F(I,J-d)+p2*F(I,J)+p3*(F(I,J+d))/p \end{aligned} \qquad (3a)$$

where ∂x (I, J) and ∂y (I, J) are the gradient magnitude in x and y directions at pixel (I, J) of the image respectively, p1, p2 are positive numbers, p2 is negative number, and d is a constant expressed as step of the gradients p = p1+p2+p3;

estimating local orientation of each block (B(k)) centered at pixel (I, J) by computing

$$\xi x(I,J)=\sum_{(u,v)\in B(k)}\sum 2*\partial x(u,v)*\partial y(u,v), \quad (3b)$$

$$\zeta y(I,J)=\sum_{(u,v)\in B(k)}\sum (\partial\partial x(u,v)*\partial\partial y(u,v)), \quad (3c)$$

$$\theta(I,J)=(1/2)\mathrm{atan}\{\xi x(I,J)/\zeta y(I,J)\} \quad (3d)$$

Where $\theta(I,J)$ is an estimate of the local ridge orientation at the block centered at pixel (I, J);

computing ridge oriental vector as

$$P=(1/n)\sum_{(I,J)\in R}\cos(2*\theta(I,J)) \quad (4a)$$

$$Q=(1/n)\sum_{(I,J)\in R}\sin(2*\theta(I,J)) \quad (4b)$$

where P and Q are first and second components of the ridge oriental vector, respectively, and n is the total number of pixels calculated at the local region R;

for each block centered at pixel (I, J), computing the minimal value and maximal value the pixel;

for each block centered at pixel (I, J), computing a sequence of pixels seq(I, J) that take minimal and maximal value along the direction (a, b), where (a, b) is orthogonal vector of the main oriental vector (p, q);

computing freq(I, J), frequency of seq(I, J) at each block centered at pixel (I, J) according to the differential value between connected elements in seq(I, J); and

estimating a local ridge frequency W by computing

$$W=(1/K)\sum_{(u,v)\in wnd(I,J)}\sum freq(u,v) \quad . \text{ (5)}$$

15. The method of claim 11, wherein the step of mapping comprises the step of determining weight coefficients, A1, A2, A3, A4, A5 and A6 of a partial differential equation

$$A1\frac{\partial^2 U}{\partial X^2}+A2\frac{\partial^2 U}{\partial X \partial Y}+A3\frac{\partial^2 U}{\partial Y^2}+A4\frac{\partial U}{\partial X}+A5\frac{\partial U}{\partial Y}+A6*U=0 \qquad (1)$$

by computing

$$A1=P*P*(P*P+Q*Q)*W*W, \qquad (6a)$$
$$A2=2*(sqrt(u*u-P*P*W*W)*sqrt(v-Q*Q*W*W))/W, \qquad (6b)$$
$$A3=Q*Q(P*P+Q*Q)*W*W, \qquad (6c)$$
$$A4=u*q+v, \qquad (6d)$$
$$A5=-v*p-u, \text{ and} \qquad (6e)$$
$$A6=a*(P*P+Q*Q)+b \qquad (6f)$$

where a, b, u, v are constants.

16. The method of claim 12, wherein the step of setting boundary condition comprises the steps of:

denoting B as a discrete boundary in a region R; and computing

$$U\Big|_{(x,y)\in S}=B1(x,y), \qquad \frac{\partial U}{\partial s}\Big|_{(x,y)\in S}=B2(x,y) \qquad (7)$$

where S is a continuous boundary defined on the discrete boundary B, and B1(x, y) and B2(x, y) are the continuous function and differentiable function defined on the boundary S, respectively.

17. The method of claim 1, wherein the step of determining simultaneous difference equations comprises the steps of:

integralizing the image to produce a group of integral points within a region R and an integral boundary IB;

discretizing the image based on the mesh points for numerating the partial differential equation and a boundary condition; and

transforming the discretizied image by solving each mesh point in the image to determine the simultaneous difference equations.

18. The method of claim 17, wherein the step of integralizing comprises the steps of:

denoting two directions of the coordinate axes of the fingerprint image as X-direction and Y-direction; and

along the X-direction and Y-direction, computing integral points at a desired step length H as follow

$$X(I) = X0 + I*H, \quad I = 0, 1, 2, \ldots\ldots, W(F), \tag{8a}$$

$$Y(J) = Y0 + J*H, \quad J = 0, 1, 2, \ldots\ldots, H(F), \tag{8b}$$

where, (X0, Y0) is top left point of the image, W(F) is the width of the image and H(F) is the height of the image.

19. The method of claim 17, wherein the step of discretizing comprises the steps of:

computing the derivatives in the partial differential equation

$$A1\frac{\partial^2 U}{\partial X^2}+A2\frac{\partial^2 U}{\partial X\partial Y}+A3\frac{\partial^2 U}{\partial Y^2}+A4\frac{\partial U}{\partial X}+A5\frac{\partial U}{\partial Y}+A6*U=0 \tag{1}$$

with respect to each inner mesh point as

$$\frac{\partial U}{\partial X}\approx[U(X+H,Y)-U(X,Y)]/H \tag{9a}$$

$$\frac{\partial U}{\partial Y}\approx[U(X,Y+H)-U(X,Y)]/H \tag{9b}$$

$$\frac{\partial^2 U}{\partial X^2} \approx [U(X+H,Y)-2*U(X,Y)+U(X-H,Y)]/H*H) \qquad (9c)$$

$$\frac{\partial^2 U}{\partial Y^2} \approx [U(X,Y+H)-2*U(X,Y)+U(X,Y-H)]/(H*H) \qquad (9d)$$

$$\frac{\partial^2 U}{\partial X \partial X} \approx [U(X+H,Y+H)-U(X+H,Y)-U(X,Y+H)+U(X,Y)]/(H*H) \qquad (9e)$$

where (X, Y) is inner mesh point in region R, IMP(R);

discretizing the boundary condition

$$U\Big|_{(x,y)\in S}=B1(x,y), \qquad \frac{\partial U}{\partial s}\Big|_{(x,y)\in S}=B2(x,y) \qquad (7)$$

; and

combining the numerical derivatives of the partial differential equation and numerical boundary condition.

20. The method of claim 19, wherein the step of discretizing the boundary condition comprises the steps of:

replacing the continuous function U(X, Y) in the boundary condition with discrete function F(I, J), wherein (I, J) is inner mesh point of a region in the image;

replacing the continuous function B1(x, y) in the boundary condition with a numerical function according to

$$D1(X,Y)=f1*F(X,Y)+f2, \qquad (X,Y)\in IB \qquad (10)$$

where f1 and f2 are constants that are predetermined according to brightness and contrast of the image, and F(X, Y) is the gray value at point (X, Y) on the integral boundary IB; and

replacing the continuous function B2(x, y) in the boundary condition with a numerical function according to

$$D2(X,Y)=f1*[F(X1,Y1)-F(X,Y)]/h, \qquad (X,Y)\in IB$$
$$h=sqrt((X1-X)*(X1-X)+(Y1-Y)*(Y1-Y)); \qquad (11)$$

where (X1, Y1) is an integral point on IB selected as the next adjacent point along the boundary line IB.

21. The method of claim 1, wherein the step of mapping the solutions comprises the steps of:

for each region R, computing minimum value min (R) and maximum value max (R) in the solution;

computing ratio value r (R)= 255/(max (R) - min (R));

for each point (I, J) in the region R, assigning v(I, J) * 3 as the solution at point (I, J);

computing W(I, J) = r(R)*(v(I, J)-min(R)) as the mapping of w(I, J) into gray level byte at the position (I, J); and

enhancing the region R is by placing the value W(I, J) at position (I, J).

22. A method performed by a computer for extracting features from an image, the method comprising the steps of:

establishing a mathematical model according to regional conditions in the image;

converting the mathematical model into numerical equations;

solving the numerical equations; and

transferring the solutions of the numerical equations to respective regions of the image.

23. The method of claim 22, wherein the step of establishing a mathematical model comprises the steps of:

forming a partial differential equation;

calculating a plurality of intrinsic properties of the image according to image ridge pattern;

mapping the plurality of intrinsic properties into coefficients of the partial differential equation; and

determining a boundary condition for the partial differential equation from the image to establish a relationship

between properties of the image and the partial differential equation.

24. The method of claim 22, wherein the step of establishing a mathematical model comprises the steps of:

forming a partial differential equation;

determining initial conditions for the partial differential equation; and

determining boundary condition for the partial differential equation.

25. The method of claim 24, wherein the step of determining initial conditions comprises the steps of:

normalizing the image to reduce variations in gray-level values along ridges of the image;

estimating property values the image; and

mapping the estimated property values into weight coefficients of the partial differential equation.

26. The method of claim 24, wherein the step of determining boundary condition comprises the steps of:

drawing a close boundary within the image; and

setting boundary condition on the drawn boundary.

27. The method of claim 25, wherein the step of normalizing comprises the steps of:

determining M, mean of the gray-level in a region R by computing

$$M=(1/N)\sum\sum_{(I,J)\in R} F(I,J) \qquad (2a)$$

where N is total number pixels in the region R; F(I, J) is gray value of the image at point (I, J);

determining V, variance of the region R by computing

$$V=(1/N)\sum_{(I,J)\in R}\sum(F(I,J)-M(F))*(F(I,J)-M(F)) \quad (2b);$$ and

determining a normalized region R by computing

$$R(I,J)=m+\mathrm{sqrt}((v*(F(I,J)-M)*(F(I,J)-M))/V), \text{if } (I,J)>M;$$
$$R(I,J)=m-\mathrm{sqrt}((v*(F(I,J)-M)*(F(I,J)-M))/V), \text{ otherwise} \quad (2c)$$

where m and v are the desired mean and variance values, respectively.

28. The method of claim 25, wherein the step of estimating property values comprises the steps of:

dividing a region R into blocks of size b*b as B(k);

computing gradients at each pixel in R as

$$\partial x(I,J)=(p1*F(I-d,J)+p2*F(I,J)+p3*(F(I+d,J))/p,$$
$$\partial y(I,J)=(p1*F(I,J-d)+p2*F(I,J)+p3*(F(I,J+d))/p \quad (3a)$$

where ∂x (I, J) and ∂y (I, J) are the gradient magnitude in x and y directions at pixel (I, J) of the image respectively, p1, p2 are positive numbers, p2 is negative number, and d is a constant expressed as step of the gradients p = p1+p2+p3;

estimating local orientation of each block (B(k)) centered at pixel (I, J) by computing

$$\xi x(I,J)=\sum_{(u,v)\in B(k)}\sum 2*\partial x(u,v)*\partial y(u,v), \quad (3b)$$

$$\zeta y(I,J)=\sum_{(u,v)\in B(k)}\sum(\partial\partial x(u,v)*\partial\partial y(u,v)), \quad (3c)$$

$$\theta(I,J)=(1/2)\mathrm{atan}\{\xi x(I,J)/\zeta y(I,J)\} \quad (3d)$$

where $\theta(I,J)$ is an estimate of the local ridge orientation at the block centered at pixel (I, J);

computing ridge oriental vector as

$$P=(1/n)\sum_{(I,J)\in R}\cos(2*\theta(I,J)) \tag{4a}$$

$$Q=(1/n)\sum_{(I,J)\in R}\sin(2*\theta(I,J)) \tag{4b}$$

where P and Q are first and second components of the ridge oriental vector, respectively, and n is the total number of pixels calculated at the local region R;

for each block centered at pixel (I, J), computing the minimal value and maximal value the pixel;

for each block centered at pixel (I, J), computing a sequence of pixels seq(I, J) that take minimal and maximal value along the direction (a, b), where (a, b) is orthogonal vector of the main oriental vector (p, q);

computing freq(I, J), frequency of seq(I, J) at each block centered at pixel (I, J) according to the differential value between connected elements in seq(I, J); and

estimating a local ridge frequency W by computing

$$W=(1/K)\sum_{(u,v)\in wnd(I,J)}\sum freq(u,v). \tag{5}$$

29. The method of claim 25, wherein the step of mapping comprises the step of determining weight coefficients, A1, A2, A3, A4, A5 and A6 of a partial differential equation

$$A1\frac{\partial^2 U}{\partial X^2}+A2\frac{\partial^2 U}{\partial X\partial Y}+A3\frac{\partial^2 U}{\partial Y^2}+A4\frac{\partial U}{\partial X}+A5\frac{\partial U}{\partial Y}+A6*U=0 \tag{1}$$

by computing

$$A1=P*P*(P*P+Q*Q)*W*W, \quad (6a)$$

$$A2=2*(sqrt(u*u-P*P*W*W)*sqrt(v-Q*Q*W*W))/W, \quad (6b)$$

$$A3=Q*Q(P*P+Q*Q)*W*W, \quad (6c)$$

$$A4=u*q+v, \quad (6d)$$

$$A5=-v*p-u, \text{ and} \quad (6e)$$

$$A6=a*(P*P+Q*Q)+b \quad (6f)$$

where a, b, u, v are constants.

30. The method of claim 26, wherein the step of setting boundary condition comprises the steps of:

denoting B as a discrete boundary in a region R; and computing

$$U\Big|_{(x,y)\in S}=B1(x,y), \qquad \frac{\partial U}{\partial s}\Big|_{(x,y)\in S}=B2(x,y) \quad (7)$$

where S is a continuous boundary defined on the discrete boundary B, and B1(x, y) and B2(x, y) are the continuous function and differentiable function defined on the boundary S, respectively.

31. The method of claim 22, wherein the step of converting the mathematical model comprises the steps of:

determining simultaneous difference equations;

integralizing the image to produce a group of integral points within a region R and an integral boundary IB;

discretizing the image based on mesh points for numerating the partial differential equation and a boundary condition; and

transforming the discretizied image by solving each mesh point in the image to determine the simultaneous difference equations.

32. The method of claim 31, wherein the step of integralizing comprises the steps of:

denoting two directions of the coordinate axes of the fingerprint image as X-direction and Y-direction; and

along the X-direction and Y-direction, computing integral points at a desired step length H as follow

$$X(I) = X0 + I*H, \quad I = 0, 1, 2, \ldots\ldots, W(F), \qquad (8a)$$

$$Y(J) = Y0 + J*H, \quad J = 0, 1, 2, \ldots\ldots, H(F), \qquad (8b)$$

where, (X0, Y0) is top left point of the image, W(F) is the width of the image and H(F) is the height of the image.

33. The method of claim 31, wherein the step of discretizing comprises the steps of:

computing the derivatives in the partial differential equation

$$A1\frac{\partial^2 U}{\partial X^2}+A2\frac{\partial^2 U}{\partial X\partial Y}+A3\frac{\partial^2 U}{\partial Y^2}+A4\frac{\partial U}{\partial X}+A5\frac{\partial U}{\partial Y}+A6*U=0 \qquad (1)$$

with respect to each inner mesh point as

$$\frac{\partial U}{\partial X}\approx[U(X+H,Y)-U(X,Y)]/H \qquad (9a)$$

$$\frac{\partial U}{\partial Y}\approx[U(X,Y+H)-U(X,Y)]/H \qquad (9b)$$

$$\frac{\partial^2 U}{\partial X^2}\approx[U(X+H,Y)-2*U(X,Y)+U(X-H,Y)]/H*H) \qquad (9c)$$

$$\frac{\partial^2 U}{\partial Y^2}\approx[U(X,Y+H)-2*U(X,Y)+U(X,Y-H)]/(H*H) \qquad (9d)$$

$$\frac{\partial^2 U}{\partial X\partial X}\approx[U(X+H,Y+H)-U(X+H,Y)-U(X,Y+H)+U(X,Y)]/(H*H) \qquad (9e)$$

where (X, Y) is inner mesh point in region R, IMP(R);

discretizing the boundary condition

$$U\Big|_{(x,y)\in S}=B1(x,y), \qquad \frac{\partial U}{\partial s}\Big|_{(x,y)\in S}=B2(x,y) \qquad ; \text{ and} \qquad (7)$$

combining the numerical derivatives of the partial differential equation and numerical boundary condition.

34. The method of claim 33, wherein the step of discretizing the boundary condition comprises the steps of:

replacing the continuous function U(X, Y) in the boundary condition with discrete function F(I, J), wherein (I, J) is inner mesh point of a region in the image;

replacing the continuous function B1(x, y) in the boundary condition with a numerical function according to

$$D1(X,Y)=f1*F(X,Y)+f2, \qquad (X,Y)\in IB \tag{10}$$

where f1 and f2 are constants that are predetermined according to brightness and contrast of the image, and F(X, Y) is the gray value at point (X, Y) on the integral boundary IB; and

replacing the continuous function B2(x, y) in the boundary condition with a numerical function according to

$$\begin{aligned} &D2(X,Y)=f1*[F(X1,Y1)-F(X,Y)]/h, \qquad (X,Y)\in IB \\ &h=sqrt((X1-X)*(X1-X)+(Y1-Y)*(Y1-Y)); \end{aligned} \tag{11}$$

where (X1, Y1) is an integral point on IB selected as the next adjacent point along the boundary line IB.

35. The method of claim 22, wherein the step of transferring the solutions comprises the steps of:

for each region R in the image, computing minimum value min (R) and maximum value max (R) in the solution;

computing ratio value r (R)= 255/(max (R) - min (R));

for each point (I, J) in the region R, assigning v(I, J) * 3 as the solution at point (I, J);

computing W(I, J) = r(R)*(v(I, J)-min(R)) as the mapping of w(I, J) into gray level byte at the position (I, J); and

enhancing the region R is by placing the value W(I, J) at position (I, J).

36. The method of claim 22, wherein the image is one or more of a fingerprint image, a facial image, a hand-palm image, an eye iris, an eye retina, and a texture image.

37. A digital signal processor (DSP) having stored thereon a set of instructions including instructions for generating geometric pattern from an image having a plurality of ridges and mesh points, when executed, the instructions cause the DSP to perform the steps of:

forming a partial differential equation by transferring values for positions in the image to corresponding coefficients of the partial differential equation;

determining simultaneous difference equations corresponding to the partial differential equation and the image mesh points;

solving the simultaneous difference equations; and

mapping the solutions of the simultaneous difference equations to respective positions on the image to determine features of the image.

38. The DSP of claim 37, wherein the step of forming a partial differential equation comprises the steps of:

determining initial conditions for the partial differential equation; and

determining boundary condition for the partial differential equation.

39. The DSP of claim 38, wherein the step of determining initial conditions comprises the steps of:

normalizing the image to reduce variations in gray-level values along ridges of the image;

estimating property values the image; and

mapping the estimated property values into weight coefficients of the partial differential equation.

40. The DSP of claim 38, wherein the step of determining boundary condition comprises the steps of:

drawing a close boundary within the image; and

setting boundary condition on the drawn boundary.

41. The DSP of claim 39, wherein the step of normalizing comprises the steps of:

determining M, mean of the gray-level in a region R by computing

$$M=(1/N)\sum_{(I,J)\in R}\sum F(I,J) \qquad (2a)$$

where N is total number pixels in the region R; F(I, J) is gray value of the image at point (I, J);

determining V, variance of the region R by computing

$$V=(1/N)\sum_{(I,J)\in R}\sum (F(I,J)-M(F))*(F(I,J)-M(F)) \qquad (2b);\ \text{and}$$

determining a normalized region R by computing

$$\begin{aligned} &R(I,J)=m+sqrt((v*(F(I,J)-M)*(F(I,J)-M))/V), \text{if } (I,J)>M; \\ &R(I,J)=m-sqrt((v*(F(I,J)-M)*(F(I,J)-M))/V), \text{otherwise} \end{aligned} \qquad (2c)$$

where m and v are the desired mean and variance values, respectively.

42. The DSP of claim 39, wherein the step of estimating property values comprises the steps of:

dividing a region R into blocks of size b*b as B(k);

computing gradients at each pixel in R as

$$\partial x(I,J)=(p1*F(I-d,J)+p2*F(I,J)+p3*(F(I+d,J))/p,$$
$$\partial y(I,J)=(p1*F(I,J-d)+p2*F(I,J)+p3*(F(I,J+d))/p \quad (3a)$$

where ∂x (I, J) and ∂y (I, J) are the gradient magnitude in x and y directions at pixel (I, J) of the image respectively, p1, p2 are positive numbers, p2 is negative number, and d is a constant expressed as step of the gradients p = p1+p2+p3;

estimating local orientation of each block (B(k)) centered at pixel (I, J) by computing

$$\xi x(I,J)=\sum_{(u,v)\in B(k)}\sum 2*\partial x(u,v)*\partial y(u,v), \quad (3b)$$
$$\zeta y(I,J)=\sum_{(u,v)\in B(k)}\sum (\partial\partial x(u,v)*\partial\partial y(u,v)), \quad (3c)$$
$$\theta(I,J)=(1/2)\mathrm{atan}\{\xi x(I,J)/\zeta y(I,J)\} \quad (3d)$$

Where $\theta(I,J)$ is an estimate of the local ridge orientation at the block centered at pixel (I, J);

computing ridge oriental vector as

$$P=(1/n)\sum_{(I,J)\in R}\cos(2*\theta(I,J)) \quad (4a)$$
$$Q=(1/n)\sum_{(I,J)\in R}\sin(2*\theta(I,J)) \quad (4b)$$

Where P and Q are first and second components of the ridge oriental vector, respectively, and n is the total number of pixels calculated at the local region R;

for each block centered at pixel (I, J), computing the minimal value and maximal value the pixel;

for each block centered at pixel (I, J), computing a sequence of pixels seq(I, J) that take minimal and maximal value along the direction (a, b), where (a, b) is orthogonal vector of the main oriental vector (p, q);

computing freq(I, J), frequency of seq(I, J) at each block centered at pixel (I, J) according to the differential value between connected elements in seq(I, J); and

estimating a local ridge frequency W by computing

$$W=(1/K)\sum_{(u,v)\in wnd(I,J)}\sum freq(u,v) \quad . (5)$$

43. The DSP of claim 39, wherein the step of mapping comprises the step of determining weight coefficients, A1, A2, A3, A4, A5 and A6 of a partial differential equation

$$A1\frac{\partial^2 U}{\partial X^2}+A2\frac{\partial^2 U}{\partial X\partial Y}+A3\frac{\partial^2 U}{\partial Y^2}+A4\frac{\partial U}{\partial X}+A5\frac{\partial U}{\partial Y}+A6*U=0 \quad (1)$$

by computing

$$A1=P*P*(P*P+Q*Q)*W*W, \quad (6a)$$
$$A2=2*(sqrt(u*u-P*P*W*W)*sqrt(v-Q*Q*W*W))/W, \quad (6b)$$
$$A3=Q*Q(P*P+Q*Q)*W*W, \quad (6c)$$
$$A4=u*q+v, \quad (6d)$$
$$A5=-v*p-u, \text{ and} \quad (6e)$$
$$A6=a*(P*P+Q*Q)+b \quad (6f)$$

where a, b, u, v are constants.

44. The DSP of claim 40, wherein the step of setting boundary condition comprises the steps of:

denoting B as a discrete boundary in a region R; and computing

$$U\Big|_{(x,y)\in S}^{=B1(x,y),} \qquad \frac{\partial U}{\partial s}\Big|_{(x,y)\in S}^{=B2(x,y)} \qquad (7)$$

where S is a continuous boundary defined on the discrete boundary B, and B1(x, y) and B2(x, y) are the continuous function and differentiable function defined on the boundary S, respectively.

45. The DSP of claim 37, wherein the step of determining simultaneous difference equations comprises the steps of:

integralizing the image to produce a group of integral points within a region R and an integral boundary IB;

discretizing the image based on the mesh points for numerating the partial differential equation and a boundary condition; and

transforming the discretizied image by solving each mesh point in the image to determine the simultaneous difference equations.

46. The DSP of claim 45, wherein the step of integralizing comprises the steps of:

denoting two directions of the coordinate axes of the fingerprint image as X-direction and Y-direction; and

along the X-direction and Y-direction, computing integral points at a desired step length H as follow

X(I) = X0 + I*H, I = 0, 1, 2, ..., W(F), (8a)

Y(J) = Y0 + J*H, J = 0, 1, 2, ..., H(F), (8b)

where, (X0, Y0) is top left point of the image, W(F) is the width of the image and H(F) is the height of the image.

47. The DSP of claim 45, wherein the step of discretizing comprises the steps of:

computing the derivatives in the partial differential equation

$$A1\frac{\partial^2 U}{\partial X^2}+A2\frac{\partial^2 U}{\partial X \partial Y}+A3\frac{\partial^2 U}{\partial Y^2}+A4\frac{\partial U}{\partial X}+A5\frac{\partial U}{\partial Y}+A6*U=0 \qquad (1)$$

with respect to each inner mesh point as

$$\frac{\partial U}{\partial X}\approx[U(X+H,Y)-U(X,Y)]/H \qquad (9a)$$

$$\frac{\partial U}{\partial Y}\approx[U(X,Y+H)-U(X,Y)]/H \qquad (9b)$$

$$\frac{\partial^2 U}{\partial X^2}\approx[U(X+H,Y)-2*U(X,Y)+U(X-H,Y)]/H*H) \qquad (9c)$$

$$\frac{\partial^2 U}{\partial Y^2}\approx[U(X,Y+H)-2*U(X,Y)+U(X,Y-H)]/(H*H) \qquad (9d)$$

$$\frac{\partial^2 U}{\partial X \partial X}\approx[U(X+H,Y+H)-U(X+H,Y)-U(X,Y+H)+U(X,Y)]/(H*H) \qquad (9e)$$

where (X, Y) is inner mesh point in region R, IMP(R);

discretizing the boundary condition

$$U\Big|_{(x,y)\in S}^{=B1(x,y),} \qquad \frac{\partial U}{\partial s}\Big|_{(x,y)\in S}^{=B2(x,y)} \quad ;\text{ and} \qquad (7)$$

combining the numerical derivatives of the partial differential equation and numerical boundary condition.

48. The DSP of claim 47, wherein the step of discretizing the boundary condition comprises the steps of:

replacing the continuous function U(X, Y) in the boundary condition with discrete function F(I, J), wherein (I, J) is inner mesh point of a region in the image;

replacing the continuous function B1(x, y) in the boundary condition with a numerical function according to

$$D1(X,Y)=f1*F(X,Y)+f2, \qquad (X,Y)\in IB \qquad (10)$$

where f1 and f2 are constants that are predetermined according to brightness and contrast of the image, and F(X,

Y) is the gray value at point (X, Y) on the integral boundary IB; and

replacing the continuous function B2(x, y) in the boundary condition with a numerical function according to

$$D2(X,Y)=f1*[F(X1,Y1)-F(X,Y)]/h, \qquad (X,Y)\in IB$$
$$h=sqrt((X1-X)*(X1-X)+(Y1-Y)*(Y1-Y)); \tag{11}$$

where (X1, Y1) is an integral point on IB selected as the next adjacent point along the boundary line IB.

49. The DSP of claim 37, wherein the step of mapping the solutions comprises the steps of:

for each region R, computing minimum value min (R) and maximum value max (R) in the solution;

computing ratio value r (R)= 255/(max (R) - min (R));

for each point (I, J) in the region R, assigning v(I, J) * 3 as the solution at point (I, J);

computing W(I, J) = r(R)*(v(I, J)-min(R)) as the mapping of w(I, J) into gray level byte at the position (I, J); and

enhancing the region R is by placing the value W(I, J) at position (I, J).

50. The DSP of claim 37, wherein the image is one or more of a finger print, a facial image, a hand-palm image, an eye iris, an eye retina, and a texture image.

51. A method performed by a computer for biometric image processing, the DSP comprising the steps of:

establishing numerical relationship between visual appearance of the biometric image; and

approximating solutions of a partial differential equation with a boundary condition according to the established numerical relationship to determine features of the biometric image.

52. The method of claim 51, wherein the step of establishing numerical relationship comprises the steps of:

forming a partial differential equation;

calculating a plurality of intrinsic properties of the image according to image ridge pattern;

mapping the plurality of intrinsic properties into coefficients of the partial differential equation; and

determining a boundary condition for the partial differential equation from the image to establish a relationship between properties of the image and the partial differential equation.

53. The method of claim 52, wherein the step of forming a partial differential equation comprises the steps of:

determining initial conditions for the partial differential equation; and

determining boundary condition for the partial differential equation.

54. The method of claim 53, wherein the step of determining initial conditions comprises the steps of:

normalizing the image to reduce variations in gray-level values along ridges of the image;

estimating property values the image; and

mapping the estimated property values into weight coefficients of the partial differential equation.

55. The method of claim 53, wherein the step of determining boundary condition comprises the steps of:

drawing a close boundary within the image; and

setting boundary condition on the drawn boundary.

56. The method of claim 51, wherein the step of approximating solutions comprises the steps of:

integralizing the image to produce a group of integral points within a region R and an integral boundary IB;

discretizing the image based on mesh points for numerating a partial differential equation and a boundary condition;

transforming the discretizied image by solving each mesh point in the image to determine the simultaneous difference equations;

replacing the continuous function U(X, Y) in the boundary condition with discrete function F(I, J), wherein (I, J) is inner mesh point of a region in the image;

replacing the continuous function B1(x, y) in the boundary condition with a numerical function according to

$$D1(X,Y)=f1*F(X,Y)+f2, \qquad (X,Y)\in IB \tag{10}$$

where f1 and f2 are constants that are predetermined according to brightness and contrast of the image, and F(X, Y) is the gray value at point (X, Y) on the integral boundary IB; and

replacing the continuous function B2(x, y) in the boundary condition with a numerical function according to

$$\begin{aligned} &D2(X,Y)=f1*[F(X1,Y1)-F(X,Y)]/h, \qquad (X,Y)\in IB \\ &h=sqrt((X1-X)*(X1-X)+(Y1-Y)*(Y1-Y)); \end{aligned} \tag{11}$$

where (X1, Y1) is an integral point on IB selected as the next adjacent point along the boundary line IB.

57. The method of claim 56, wherein the step of integralizing comprises the steps of:

denoting two directions of the coordinate axes of the fingerprint image as X-direction and Y-direction; and

along the X-direction and Y-direction, computing integral points at a desired step length H as follow

$$X(I) = X0 + I*H, \qquad I = 0, 1, 2, \ldots\ldots, W(F), \tag{8a}$$

$$Y(J) = Y0 + J*H, \qquad J = 0, 1, 2, \ldots\ldots, H(F), \tag{8b}$$

where, (X0, Y0) is top left point of the image, W(F) is the width of the image and H(F) is the height of the image.

58. The method of claim 56, wherein the step of discretizing comprises the steps of:

computing the derivatives in the partial differential equation

$$A1\frac{\partial^2 U}{\partial X^2}+A2\frac{\partial^2 U}{\partial X\partial Y}+A3\frac{\partial^2 U}{\partial Y^2}+A4\frac{\partial U}{\partial X}+A5\frac{\partial U}{\partial Y}+A6*U=0 \qquad (1)$$

with respect to each inner mesh point as

$$\frac{\partial U}{\partial X}\approx[U(X+H,Y)-U(X,Y)]/H \qquad (9a)$$

$$\frac{\partial U}{\partial Y}\approx[U(X,Y+H)-U(X,Y)]/H \qquad (9b)$$

$$\frac{\partial^2 U}{\partial X^2}\approx[U(X+H,Y)-2*U(X,Y)+U(X-H,Y)]/H*H) \qquad (9c)$$

$$\frac{\partial^2 U}{\partial Y^2}\approx[U(X,Y+H)-2*U(X,Y)+U(X,Y-H)]/(H*H) \qquad (9d)$$

$$\frac{\partial^2 U}{\partial X\partial X}\approx[U(X+H,Y+H)-U(X+H,Y)-U(X,Y+H)+U(X,Y)]/(H*H) \qquad (9e)$$

where (X, Y) is inner mesh point in region R, IMP(R);

discretizing the boundary condition

$$U\Big|_{(x,y)\in S}=B1(x,y), \qquad \frac{\partial U}{\partial s}\Big|_{(x,y)\in S}=B2(x,y) \qquad ; \text{ and} \qquad (7)$$

combining the numerical derivatives of the partial differential equation and numerical boundary condition.

59. The method of claim 56, wherein the step of discretizing the boundary condition comprises the steps of:

replacing the continuous function U(X, Y) in the boundary condition with discrete function F(I, J), wherein (I, J) is inner mesh point of a region in the image;

replacing the continuous function B1(x, y) in the boundary condition with a numerical function according to

$$D1(X,Y)=f1*F(X,Y)+f2, \qquad (X,Y)\in IB \qquad (10)$$

where f1 and f2 are constants that are predetermined according to brightness and contrast of the image, and F(X, Y) is the gray value at point (X, Y) on the integral boundary IB; and

replacing the continuous function B2(x, y) in the boundary condition with a numerical function according to

$$D2(X,Y)=f1*[F(X1,Y1)-F(X,Y)]/h, \qquad (X,Y)\in IB$$
$$h=sqrt((X1-X)*(X1-X)+(Y1-Y)*(Y1-Y)); \qquad (11)$$

where (X1, Y1) is an integral point on IB selected as the next adjacent point along the boundary line IB.

60. The method of claim 56, further comprising the step of mapping the solutions of the partial differential equation to respective positions on the image to determine features of the image.

61. The method of claim 60, wherein the step of mapping the solutions comprises the steps of:

for each region R, computing minimum value min (R) and maximum value max (R) in the solution;

computing ratio value r (R)= 255/(max (R) - min (R));

for each point (I, J) in the region R, assigning v(I, J) * 3 as the solution at point (I, J);

computing W(I, J) = r(R)*(v(I, J)-min(R)) as the mapping of w(I, J) into gray level byte at the position (I, J); and

enhancing the region R is by placing the value W(I, J) at position (I, J).

62. The method of claim 51, wherein the image is one or more of a finger print, a facial image, a hand-palm image, an eye iris, an eye retina, and a texture image.